Soybean

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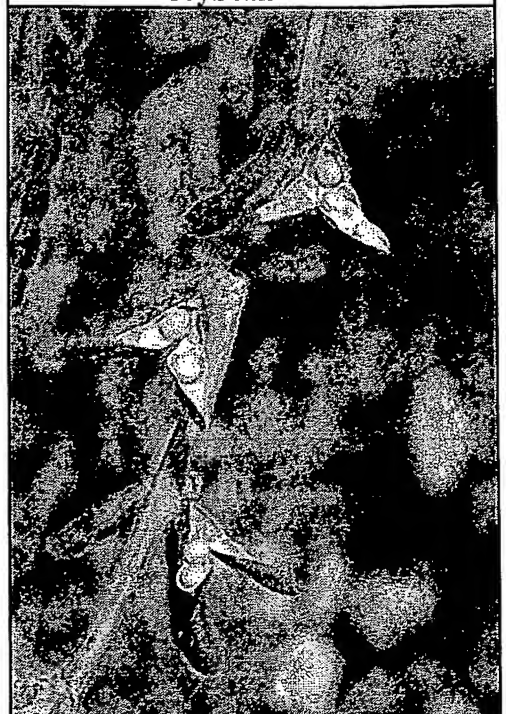
The **Soybean** (U.S.) or **Soya bean** (UK) (*Glycine max*) is a species of legume, native to eastern Asia. It is an annual plant, which may vary in growth habit and height. It may grow prostrate, not growing above 20 cm (7.8 inches); up to stiffly erect plants growing to 2 meters (6.5 feet). The pods, stems, and leaves are covered with fine brown or gray pubescence. The leaves are trifoliate (sometimes with 5 leaflets), the leaflets 6-15 cm (2-6 inches) long and 2-7 cm (1-3 inches) broad; they fall before the seeds are mature. The small, inconspicuous, self-fertile flowers are borne in the axil of the leaf and are either white or purple; The fruit is a hairy pod that grow in clusters of 3-5, with each pod 3-8 cm (1-3 inches) long and usually containing 2-4 (rarely more) seeds 5-11 mm in diameter.

Like corn and some other crops of long domestication, the relationship of the modern soybean to wild-growing species can no longer be traced with any degree of certainty. It is a cultural variety (a cultigen) with a very large number of cultivars. However, it is known that the progenitor of the modern soybean was a vine-like plant, that grew prone on the ground.

Beans are classed as pulses whereas soybeans are classed as oilseeds. The word soy is derived from the Japanese word *shoyu* (soy sauce/soya sauce).

Soybean ?



Scientific classification	
Kingdom:	Plantae
Phylum:	Magnoliophyta
Class:	Magnoliopsida
Order:	Fabales
Family:	Fabaceae
Subfamily:	Faboideae
Genus:	*Glycine*
Species:	***G. max***

Binomial name

Glycine max
(L.) Merr.

Contents

Physical characteristics

Soybeans occur in various sizes, and in several hull or seed coat colors, including black, brown, blue, yellow, and mottled. The hull of the mature bean is hard, water resistant, and protects the cotyledon and hypocotyl (or "germ") from damage. If the seed coat is "cracked" the seed will not germinate. The scar, visible on the seed coat, is called the hilum (colors include black, brown, buff, gray and yellow) and at one end of the hilum is the micropyle, or small opening in the seed coat which can allow the absorption of water.

It is a remarkable fact that seeds such as soybeans, containing very high levels of soy protein, can undergo desiccation yet survive and revive after water absorption. A.Carl Leopold, son of Aldo Leopold, set out twenty years ago to answer this very question at the Boyce Thompson Institute for Plant Research at Cornell University. Studying the survival of soybeans and corn he found each to have a range of soluble sugars carbohydrate protecting the seed's cell viability.[1] (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1075542). Patents were awarded to him in the early 1990s on techniques for protecting "biological membranes" and proteins in the dry state.

Chemical composition of the seed

The oil and protein content together account for about 60% of dry soybeans by weight; protein at 40% and oil at 20%. The remainder consists of 35% carbohydrate and about 5% ash. Soybean cultivars comprise approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyl axis or germ.

The majority of soy protein is a relatively heat-stable storage protein. It is within the nature of this heat stability of the soy protein that enables soy food products requiring high temperature cooking, such as tofu, soymilk and textured vegetable protein(soy flour) to be made.

The principal soluble carbohydrates, saccharides, of mature soybeans are the disaccharide sucrose(range 2.5-8.2%), the trisaccharide raffinose(0.1-1.0%) composed of one sucrose molecule connected to one molecule of galactose, and the tetrasaccharide stachyose(1.4 to 4.1%) composed of one sucrose connected to two molecules of galactose. While the oligosaccharides raffinose and stachyose protect the viability of the soybean seed from desiccation{see above section on physical characteristics} they are not digestable sugars and therefore contribute to flatulence and abdominal discomfort in humans and other monogastric animals. Microbial gases produced are carbon dioxide, hydrogen, nitrogen, methane, etc.

Flatulence is one of the major obstacles to fuller utilization of soybeans as food. Since soluble soy carbohydrates are found mainly in the whey and are broken down during fermentation, soy concentrate, soy protein isolates, tofu, soy sauce, and sprouted soybeans are without flatus activity. On the other hand, there maybe some beneficial effects to ingesting oligosaccharides such as raffinose and stachyose, namely, encouraging indigenous bifidobacteria in the colon against putrefactive bacteria.

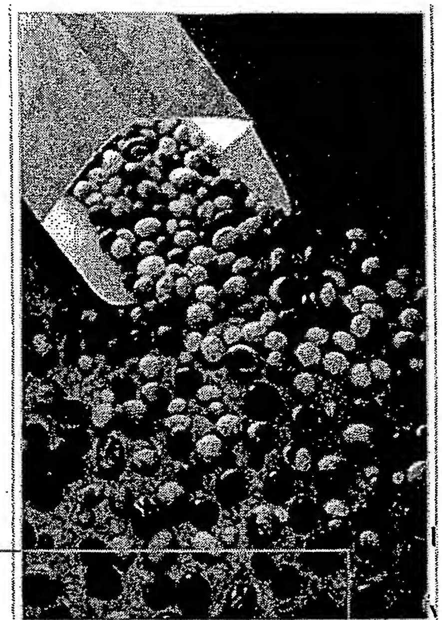
The insoluble carbohydrates in soybeans consist of the complex polysaccharides cellulose, hemicellulose, and pectin. The majority of soybean carbohydrates can be classed as belonging to dietary fiber.

Cultivation

Soybeans are an important global crop, with political ramifications. It is grown for its oil and protein. The bulk of the crop is solvent extracted for vegetable oil and the defatted soy meal is used for animal feed. A very small proportion of the crop is consumed directly for food by humans. Soybean products, however, appear in a large variety of processed foods.

Soybeans were used as food in eastern Asia long before written records, and they are still a major crop in China, Japan and Korea. They were first introduced to Europe in the early 1700s and the United States in 1765, where it was first

grown for hay. Benjamin Franklin wrote a letter in 1770 mentioning sending soybeans home from England. Soybeans did not become an important crop outside of Asia until about 1910.



Varieties of soybeans are used for many purposes.

Cultivation is successful in climates with hot summers, with optimum growing conditions in mean temperatures of 20 °C to 30 °C (68°F to 86°F); temperatures of below 20 °C and over 40 °C (68 °F, 104 °F) retard growth significantly. They can grow in a wide range of soils, with optimum growth in moist alluvial soils with a good organic content. Soybeans, like most legumes perform nitrogen fixation by establishing a symbiotic relationship with the bacterium *Bradyrhizobium japonicum* (syn. *Rhizobium japonicum*; Jordan 1982). However, for best results an inoculum of the correct strain of bacteria should be mixed with the soybean (or any legume) seed before planting. Modern crop cultivars generally reach a height of around 1 m (3 ft), and take between 80-120 days from sowing to harvesting.

Top Soy Producers - 2005 (million metric ton)	
United States	82.8
Brazil	50.2
Argentina	38.3
People's Republic of China	16.9
India	6.0
Paraguay	3.5
Canada	3.0
Bolivia	1.7
World Total	**209.5**

Source:
UN Food & Agriculture Organisation (FAO)[2] (http://faostat.fao.org/faostat/form?collection=Production.Crops.Primary&Domain=Production&servlet=1&hasbulk=0&version=ext&language=EN)

to sout but 45 perc of the worl soyb area, and 55 perc of prod is in the United States. The U.S. produced 75 million metric tons of soybeans in 2000, of which more than one-third was exported. Other leading producers are Brazil, Argentina, China, and India.

Environmental groups, such as Greenpeace and the WWF, have reported that soybean cultivation and the threat to increase soybean cultivation in Brazil is destroying huge areas of Amazon rainforest and encouraging deforestation.

The first research on soybeans in the United States was conducted by George Washington Carver at Tuskegee, Alabama, but he decided it was too exotic a crop for the poor black farmers of the South so he turned his attention to peanuts. He also encouraged farmers to use crop rotation. Peanuts, soybeans, sweet potatoes or other plants that would replenish the soil with nitrogen and minerals were planted for two years and then cotton on the third year. A two-year rotation system alternating maize and soybeans is common in much of the U.S.

Uses

Soybeans can be broadly classified as "vegetable" (garden) or field (oil) types. Vegetable types cook more easily, have a mild nutty flavor, better texture, are larger in size, higher in protein, and lower in oil than field types. Tofu and soymilk producers prefer the higher protein cultivars bred from vegetable soybeans originally brought to the United States in the late 1930s. The "garden" cultivars are generally not suitable for mechanical combine harvesting because they have a

tendency for the pods to shatter on reaching maturity.

Among the legumes, the soybean, also classed as an oilseed, is pre-eminent for its high (38-45%) protein content as well as its high (20%) oil content. Soybeans are the leading agricultural export in the United States. The bulk of the soybean crop is grown for oil production, with the high-protein defatted and "toasted" soy meal used as livestock feed. A smaller percentage of soybeans are used directly for human consumption, particularly in Asia.

Soybeans may be boiled whole in their green pod and served with salt, under the Japanese name *edamame*. Soybeans prepared this way are a popular local snack in Hawai'i, where, as in Japan, China, and Korea, the bean and products made from the bean (miso, natto, tofu, douchi, doenjang, ganjang and others) are a significant part of the diet.

The beans can be processed in a variety of ways. Common forms of soy (or *soya*) include soy meal (used as animal feed), soy flour, "soy milk", tofu, textured vegetable protein (TVP, which is made into a wide variety of vegetarian foods, some of them intended to imitate meat), tempeh, soy lecithin and soybean oil. Soybeans are also the primary ingredient involved in the production of soy sauce (or *shoyu*).

Oil

Soybeans grow throughout Asia and North and South America.

In processing soybeans for oil extraction and subsequent soy flour production, selection of high quality, sound, clean, dehulled yellow soybeans is very important. Soybeans having a dark colored seed coat, or even beans with a dark hilum will inadvertently leave dark specks in the flour, an undesirable factor when used in food products. All commercial soybeans in the United States are yellow or yellow brown.

To produce soybean oil, the soybeans are cracked, adjusted for moisture content, rolled into flakes and solvent-extracted with commercial hexane. The oil is then refined, blended for different applications, and sometimes hydrogenated. Soybean oils, both liquid and partially hydrogenated, are exported abroad, sold as "vegetable oil," or end up in a wide variety of processed foods. The remaining soybean husks are used mainly as animal feed.

The major unsaturated fatty acids in soybean oil triglycerides are linolenic acid,C18:3; linoleic acid, C-18:2; and oleic acid,C-18:1. Soybean oil has a relatively high proportion, 7-10%, of oxidation prone linolenic acid, which is an undesirable property for continuous service, such as in a restaurant. Two companies, Monsanto and DuPont/Bunge in 2004 introduced low linolenic,(C18:3; cis-9, cis-12, cis-15 octadecatrienoic acid) Roundup Ready soybeans: the former introduced a new soybean seed variety called "Vistive" and the latter Pioneer seed variety 93M20. Dupont/Bunge is marketing its low linolenic soybean oil under the brand name Nutrium. The idea is that reducing or eliminating the triple unsaturated fatty acid, linolenic, also eliminates the tendency to be a paint-like drying oil producing noticeable rancidity. In the past hydrogenation reduced the unsaturation in linolenic acid but produced the unnatural trans fatty acid trans fat configuration whereas in nature the configuration is cis.

One unintended consequence of moving away from partially hydrogenated soybean oil (containing trans fatty acids) is the switch to partially saturated palm oil for frying, especially in China. This fact is resulting in a severe threat of deforestation to pristine forests in Indonesia followed by the planting of palm oil plantations. [1]

Meal

Soybean meal, the material remaining after solvent extraction of soybean flakes, with a 50% soy protein content, toasted (a misnomer because the heat treatment is with moist steam), and ground, in a hammer mill, provided the energy for the American revolution, beginning in the 1930s, of growing farm animals such as poultry and swine on an industrial scale; and more recently the aquaculture of catfish.

Flour

Soy flour refers to defatted soybeans where special care was taken during desolventizing (not toasted) in order to minimize denaturation of the protein to retain a high Nitrogen Solubility Index (NSI), for uses such as extruder texturizing (TVP). It is the starting material for production of soy concentrate and soy protein isolate.

- Defatted soy flour, is obtained from solvent extracted flakes, and contains less than 1% oil.
- Full-fat soy flour, is made from unextracted, dehulled beans, and contains about 18% to 20% oil. Due to its high oil content a specialized Alpine Fine Impact Mill must be used for grinding rather than the more common hammermill.
- Low fat soy flour, is made by adding back some oil to defatted soy flour. The lipid content varies according to specifications, usually between 4.5% and 9%.
- High fat soy flour, is produced by adding back soybean oil to defatted flour, at the level of 15%.
- Lecithinated soy flour, is made by adding soybean lecithin to defatted, low fat or high fat soy flours to increase their dispersibility and impart emulsifying properties. The lecithin content varies up to 15%.

Infant formula

Infant formulas based on soy are used by lactose-intolerant babies; and for babies that are allergic to human milk proteins and cow milk proteins. The formulas are sold in powdered, ready to feed, or concentrated liquid forms.

Substitute for existing products

Many traditional dairy products have been imitated using processed soybeans, and imitation products such as "soy milk," "soy yogurt" and "soy cream cheese" are readily available in most supermarkets. These imitation products are derived from extensive processing to produce a texture and appearance similar to the real dairy-based ones. Soy milk does not contain significant amounts of calcium, since the high calcium content of soybeans is bound to the insoluble constituents and remains in the pulp. Many manufacturers of soy milk now sell calcium-enriched products as well. Tofu often contains high amounts of this important mineral since calcium salts are used to coagulate the protein in soy milk when creating tofu. Additionally, soy protein has been found to reduce renal excretion of calcium, an effect that is reinforced by the high potassium content of soy products.

Other products

Soybeans are also used in industrial products including oils, soap, cosmetics, resins, plastics, inks, crayons, solvents, and biodiesel. Soybeans are also used as fermenting stock to make a brand of vodka.

Henry Ford promoted the soybean, helping to develop uses for it both in food and in industrial products, even demonstrating auto body panels made of soy-based plastics. Ford's interest lead to 2 bushels of soybeans being used in each Ford car as well as products like the first commercial soy milk, ice cream and all-vegetable non-dairy whipped topping.

The Ford development of so called soy-based plastics was based on the addition of soybean flour and wood flour to phenolformaldehyde plastics.

In 1931 Ford, who said, "most people dig their graves with their teeth", hired the chemists Robert Boyer and Frank Calvert in a "Quest" for artificial silk. They succeeded in making a textile fiber of spun soy protein fibers, hardened or tanned in a formaldehyde bath which was given the name Azlon by the Federal Trade Commission. Pilot plant production of Azlon reached 5000 pounds per day in 1940, but never reached the commercial market. However, Henry Ford did have the "now famous" suit made for him of Azlon which he wore on special occasions. The winning textile fiber in the "Quest" for artificial silk was, of course, Nylon a synthetic polyamide or artificial protein discovered in 1935 by Wallace H.Carothers at DuPont. [Soybeans and Soybean Products, Vol.II,edited by K.H. Markley,1951]

Today, very high quality textile fibers are made commercially from okara or soy pulp, a by- product of tofu production.

Genetic modification

Soybeans are one of the "Biotech Food" crops that are being genetically modified, and GMO soybeans are being used in an increasing number of products. Monsanto is the world's leader in genetically modified soy for the commercial market. In 1995, Monsanto introduced "Roundup Ready" (RR) soybeans that have had a complete copy of a gene (plasmid) from the bacteria, *Agrobacterium* sp. strain CP4, inserted, by means of a gene gun, into its genome that allows the transgenic plant to survive being sprayed by this non-selective, glyphosate-based herbicide. Roundup kills conventional soybeans. RR soybeans allow a farmer to reduce tillage or even to sow the seed directly into an unplowed field, known as 'No Plow' tillage, greatly reducing the soil erosion.

Currently, 81% of all soybeans cultivated for the commercial market are genetically modified. As with other "Roundup Ready" crops, concern is expressed over damage to biodiversity through the loss of wildflowers removed by the roundup treatment, and consequent loss of insects and birds that depend on them. Concern is also for the high amounts of residual toxin since the herbicide is sprayed on the soya crop repeatedly during growth.

Archer Daniels Midland (ADM) is among the largest processors of soybeans and soy products. ADM along with DOW, DuPont and Monsanto support the industry trade associations United Soybean Board (USB) and Soyfoods Association of North America (SANA). These trade associations have increased the consumption of soy products dramatically in recent years.

The dramatic increase is largely credited to the FDA approval of health claims for soy. Since the bulk of the soy grown in the US is GMO variety the chief beneficiaries of the increase are the biotech seed companies. Dr. Henney who was the FDA commissioner at the time, now sits on the board of biotech giant Astra Zeneca. Many top agency officials from the Bush Administration, have been under criticism for close ties to industry and possible financial conflicts of interest. The former USDA Secretary of Agriculture, Daniel Robert Glickman, also left to accept seats on the boards of soy related companies including Hain Foods.

From 2001 to 2004, food manufacturers in the US introduced over 1600 new foods with soy as an ingredient, averaging 400 new products per year, according to the Mintel's Global New Products Database.

From 1992 to 2003, soyfoods sales have experienced a 15% compound annual growth rate, increasing from $300 million to $3.9 billion over 11 years, as new soyfood categories have been introduced, soyfoods have been repositioned in the market place, and new customers have selected soy for health and philosophical reasons. Dramatic growth followed the FDA approval of a health claim linking soy with heart disease reduction.

Nutrition

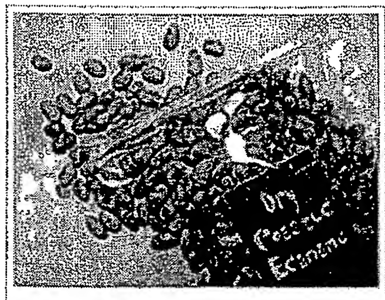
Protein

Soybeans are a source of complete protein. A complete protein is one that contains significant amounts of all the essential amino acids that must be provided to the human body because of the body's inability to synthesize them. For this reason, soy is important to many vegetarians and vegans. Soy protein is similar to that of other legume seeds, but has the highest yield per square meter of growing area, and is the least expensive source of dietary protein. The only non-legume to have an almost identical protein profile to soy is the cereal oat (*Avena sativa*), and perhaps quinoa.

The original Protein Efficiency Ratio PER method of measuring soy protein quality was found to be flawed for humans because the young rats used in the study have higher relative requirements for sulfur-containing amino acids. The FAO/WHO (1990) adapted a new method: Protein Digestibility Corrected Amino Acid Score. Based on the new method, isolated (purified) soy protein is considered equivalent in quality to animal proteins. Egg white has a score of 1.00, isolated soy protein 0.92, soy concentrate 0.99, beef 0.92. The digestibilities of some soyfoods are as follows: steamed soybeans 65.3%, tofu 92.7%, soy "milk" 92.6%, soy protein isolate 93–97% (Watanabe, et al., 1971(in Japanese) cited on page 391 in *Liu, KeShun (1997). *Soybeans: Chemistry, Technology, and Utilization*

(http://www.chipsbooks.com/soybeans.htm) Chapman & Hall.]

Vitamins and minerals


Toasted soybeans

Of any studied legume, whole soybeans have the highest levels of phytic acid, an organic acid and mineral chelator present in many plant tissues, especially bran and seeds, which binds to certain ingested minerals: calcium, magnesium, iron, and especially zinc—in the intestinal tract, and reduces the amount the body assimilates. For people with a particularly low intake of essential minerals, especially young children and those in developing countries, this effect can be undesirable. However, dietary mineral chelators help prevent over-mineralization of joints, blood vessels, and other parts of the body, which is most common in older persons. The Journal of Environmental Nutrition (April 2004 volume 27 issue 4) has also stated phytic acid may be considered a phytonutrient, providing an antioxidant effect. Scientific research [3] (http://www.nutrition.org/cgi/content/full/133/11/3778S) also indicates that it may reduce the risk of colon cancer. In spite of the chelating effects of phytic acid, soybeans remain a good source of magnesium, potassium, phosphorus, calcium, and manganese. They are also high in fiber and vitamin C.

The role of soyfoods in disease prevention

Omega-3 fatty acids

Omega-3 fatty acids, for example, linolenic acid C18-3, all cis, 9,12,15 octadecatrienoic acid (where the omega -3 refers to carbon number 3 counting from the hydrocarbon tail whereas C-15 refers to carbon number 15 counting from the carboxyl acid head) are special fat components that benefit many body functions. For instance they inhibit blood clotting, thereby reducing heart attack risk, and control body biochemicals that reduce inflammation and promote healing.

Oily fish such as salmon, and sardines are excellent sources of omega-3 fatty acids. Soybean oil and canola are the only common vegetable oils that contain omega-3s. However, the very best vegetable source of omega-3s is homemade flax meal ground in a coffee/spice grinder or blender.

Isoflavones

Soybeans also contain isoflavones, a type of phytoestrogen, that are considered by some nutritionists and physicians to be useful in the prevention of cancer, though very controversial and also blamed for some thyroid and reproductive health problems. Isoflavones are polyphenol compounds, produced primarily by beans and other legumes, including peanuts and chickpeas.

Isolated phytoestrogen like isoflavones are an active area of research. The Proceedings of the National Academy of Sciences May 28, 2002 [4] (http://www.pnas.org/content/vol99/issue11/) contains the article "The phytoestrogen genistein induces thymic and immune changes: A human health concern?"[5] (http://www.pnas.org/cgi/content/full/99/11/7616) It studies the effect of the isolated soy isoflavones genistein and daidzein, commonly found in dietary supplements and infant formulas, on adult mice with their ovaries removed. The study found the mice had thymic and immune system abnormalities and reduction in immune system activity that suggest further research into human phytoestrogen response is warranted.

From a website that advertises saliva pH alkalinity as a form of cancer protection [6] (http://www.alkalizeforhealth.net/salivaphtest.htm):

"Researchers Daniel Doerge and Daniel Sheehan, two of the Food and Drug Administration's experts on soy, signed a letter of protest, which points to studies that show a link between soy and health problems in certain animals. The two say they tried in vain to stop the FDA approval of soy because it could be misinterpreted as a broader general endorsement

beyond benefits for the heart."[7] (http://www.alkalizeforhealth.net/Lsoy2.htm)

The anti-soy website Soy Online Service has the original letter in pdf. [8] (http://www.soyonlineservice.co.nz/downloads/nctrpti.pdf)

The FDA has since publically rejected these claims due to lack of evidence and cite numerous studies that uphold the health benefits of soy foods.[9] (http://www.fda.gov/fdac/features/2000/300_soy.html)

Reduce cholesterol

In 1995, the New England Journal of Medicine (Vol. 333, No. 5) published a report from the University of Kentucky entitled, "Meta-Analysis of the Effects of Soy Protein Intake on Serum Lipids." It was financed by the PTI division of DuPont,"The Solae Co."[10] (http://www.solae.com/) St. Louis, Missouri. This meta-analysis concluded that soy protein is correlated with significant decreases in serum cholesterol, Low Density Lipoprotein LDL (bad cholesterol) and triglyceride concentrations. However, High Density Lipoprotein HDL(good cholesterol) did not increase. Soy phytoestrogens (isoflavones: genistein and daidzein) adsorbed onto the soy protein were suggested as the agent reducing serum cholesterol levels. On the basis of this research PTI, in 1998, filed a petition with FDA for a health claim that soy protein may reduce cholesterol and the risk of heart disease.

The FDA granted this health claim for soy: "25 grams of soy protein a day, as part of a diet low in saturated fat and cholesterol, may reduce the risk of heart disease." One serving, (1 cup or 240 mL) of soy milk, for instance, contains 6 or 7 grams of soy protein.

In January, 2006 an American Heart Association review (in the journal Circulation) of a decade long study of soy protein benefits casts doubt on the FDA allowed "Heart Healthy" claim for soy protein. This REVIEW of the literature compared soy protein and its component isoflavones with casein(isolated milk protein), wheat protein, and mixed animal proteins. [11] (http://circ.ahajournals.org/cgi/content/full/113/7/1034#SEC2) The review panel also found that soy isoflavones have not been shown to reduce post menopause "hot flashes" in women and the efficacy and safety of isoflavones to help prevent cancers of the breast, uterus or prostate is in question. Thus, soy isoflavone supplements in food or pills is not recommended. Among the conclusions the authors state, "In contrast, soy products such as tofu, soy butter, soy nuts, or some soy burgers should be beneficial to cardiovascular and overall health because of their high content of polyunsaturated fats, fiber, vitamins, and minerals and low content of saturated fat. Using these and other soy foods to replace foods high in animal protein that contain saturated fat and cholesterol may confer benefits to cardiovascular health."[12] (http://circ.ahajournals.org/cgi/content/full/113/7/1034#SEC5)

The original paper is in the journal Circulation: January 17,2006[13] (http://circ.ahajournals.org/cgi/content/abstract/CIRCULATIONAHA.106.171052v1?maxtoshow=&HITS=10&hits=10&RESULTFORMAT=&fulltext=soybeans%2Cfda&searchid=1138541151493_2869&FIRSTINDEX=0&search_url=http%3A%2F%2Fcirc.ahajournals.org%2Fcgi%2Fsearch&journalcode=circulationaha)

It should be noted that Cholesterol is naturally produced by all animals including humans. Phytosterol is the Sterol found in plant cells and plants contain no Cholesterol. In fact Phytosterol has been shown to have cholesterol reducing properties [14] (http://jn.nutrition.org/cgi/content/full/132/7/1983)[15] (http://www.pdrhealth.com/drug_info/nmdrugprofiles/nutsupdrugs/phy_0205.shtml)[16] (http://www.endur.com/index.cfm?fuseaction=lipid.article&id=40)[17] (http://www.cancerprev.org/Journal/Issues/17/1/43/1433)[18] (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=3942097&dopt=Abstract). Logically, replacing animal based proteins that contain cholesterol with plant based proteins that contain phytosterol would reduce the dietary intake of cholesterol and may lower blood cholesterol levels.

Cancer

A 1985 animal study showed that young rats fed large amounts of soy products as their primary food source showed an increased risk of pancreatic cancer. This is probably because rats are extremely sensitive to dietary protease inhibitors like those found in soybeans, which can disrupt the action of digestive enzymes needed to break down protein. This condition has not been found in many other animals, and is not known to occur in humans.

Potential problems with soy

Phytoestrogen in men

Because of the phytoestrogen content, some studies suggest that there is a correlation between a soybean-rich diet and a decrease in the level of testosterone in men. [19] (http://www.menshealth.com/cda/article.do?site=MensHealth&channel=health&category=other.diseases.ailments&conitem=43f999edbbbd201099edbbbd2010cfe793c [20] (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=15735098&dopt=Abstract)

Phytoestrogen in infant formula

There are some studies that suggest that a phytoestrogen in soy can lead to alterations in the proliferation and migration of intestinal cells. The effects of these alterations are unkown. [21] (http://www.ehponline.org/docs/2005/113-5/forum.html#sour) [22] (http://jn.nutrition.org/cgi/content/full/134/6/1303) However, some studies conclude there are no adverse effects in human growth, development, or reproduction as a result of the consumption of soy-based infant formula. [23] (http://jn.nutrition.org/cgi/content/full/134/5/1220S) Other studies conclude that more research is needed to answer the question of what effect phytoestrogens have on infants. [24] (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=14599051&query_hl=2&itool=pubmed_docsum) [25] (http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=15189112&query_hl=4&itool=pubmed_docsum)

Allergens

With the increased use of soybean in western diet comes also a danger of food allergies. About 8% of children in the USA are allergic to soybean proteins. The major soy allergen has been identified by scientists at USDA. Both transgenic and conventional soybean varieties without the allergenic protein have been prepared, and hopefully will soon reach the market. This will be particulalry important for preparation of baby formulas, since dual allergy to both milk and soy proteins is not uncommon.

See also

- Soy allergy
- Biodiesel
- Protein per unit area
- Soybean rust
- Soy cheese
- Soy milk
- Soy protein
- Soy pulp
- Soy sauce
- Soybean cyst nematode
- Soybean wax
- Vegetable oil
- Soy Bomb

References

1. ^ Forests in Southeast Asia Fall to Prosperity's Ax

will grow vast plantations for palm oil, an ... would develop in Indonesia as part of a $ ... *From Indonesia to Malaysia to Myanmar, ...April 29, 2006 - By JANE PERLEZ; Muktita Suhartono contributed reporting for this article. (NYT)-New York Times - World - News - 1431 words.*<\ref> Center for Science in the Public Interest (http://www.cspinet.org/palmoilreport/index.html)

In the 2002-2003 growing season, 30.6 million metric tons of soybean oil were produced worldwide, constituting about half of worldwide edible vegetable oil production, and thirty percent of all fats and oils produced, including animal fats and oils derived from tropical plants.<ref>[[United States Department of Agriculture]], Agricultural Statistics 2004. Table 3-51.
</ref>

- [26] (http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1075542)
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External links

- Soy's Thyroid Dangers (http://thyroid.about.com/cs/soyinfo/a/soy_3.htm)
- Soy Allergens (http://www.nexusmagazine.com/articles/Soy%20Allergens.html)
- Nutrition data (http://www.nutritiondata.com/foods-soybeans000000000000000000000.html)
- Evaluation of Anti-Soy Data and Anti-Soy Advocates (http://www.foodrevolution.org/what_about_soy.htm)
- Soy Online Service (http://www.soyonlineservice.co.nz/)
- Concerns Regarding Soybeans (http://www.rheumatic.org/soy.htm)
- Soya information (http://www.soya.be/)
- Soy Story: Soy in China (http://www.eatingchina.com/articles/art-soystory.html)
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SOYBEAN MEAL

Description

Soybean meal is the product remaining after extracting most of the oil from whole soybeans. The oil may be removed by solvent extraction or by an expeller process in which the beans are heated and squeezed. The nutrient composition of the oil extracted soybean meal 48 is shown in the table below.

Soybean meal is high in protein and energy and is one of the most commonly used protein supplements in North America. It is a palatable feedstuff and may be used as the major protein supplement in rations for dairy cattle.

Typical Analysis (Solvent extracted soybean meal 48)	
Dry matter	89 %
Crude Protein	48.0 %
Fat	01.0 %
Crude fiber	03.0 %
Neutral Detergent Fiber	07.1 %
Acid Detergent Fiber	05.3 %
Calcium	00.2 %
Phosphorus	0.65 %
Total Digestible Nutrients	78.0 %
Net energy—Lactation	81.1 Mcal/100 lbs

Caution: Any recommendations given here should be considered as general only and may not apply in your specific situation. All final recommendations should be made by a qualified person familiar with your particular circumstances.

SPECIFICATIONS

ALFALFA PELLETS
ALFALFA, SUNCURED
BARLEY FLOUR
BARLEY, GRAIN
BEET PULP, PELLETS
BEET PULP, PRESSED
BEET PULP, SHREDS
BLOOD MEAL, WHOLE
BONE MEAL
BONE MEAL, STEAMED
BONE PHOSPHATE
BREWERS GRAINS
BREWERS YEAST
CALCIUM PROPIONATE
CALCIUM SULFATE
CANDY PRODUCT
CANOLA MEAL
CARROT GRANULES
CARROTS, DRIED
CHEESE POWDER
CITRUS PULP
CORN COB PELLETS
CORN GLUTEN FEED
CORN GLUTEN MEAL
CORN STARCH
COTTONSEED HULLS
COTTONSEED MEAL
COTTONSEED, WHOLE
DISTILLERS GRAINS
EGG, DRIED
EGG POWDER
FEATHER MEAL
FISHMEAL
FISH MEAL, LOW ASH
FLAX SEED
HOMINY FEED
LAMB MEAL
LINSEED MEAL
LIVER MEAL
MALT SPROUTS
MALT SPROUTS #2
MEAT & BONE MEAL
MEAT MEAL 57%
MOLASSES YEAST
40/43 – SPRAY DRIED
OAT GROATS
OAT HULLS
OATMILL BY-PRODUCT
OATS
POTATO FLAKES
POTATO, MASH BLEND
POTATO, DEHY
POTATO, DRIED
POULTRY MEAL

4. Chemical and Nutritional Composition of Soybean Products

The compositional data provided in the Tables 3 and 4 (with additional details in Appendix Tables 1, 2) are better descriptors of the nutritional characteristics of soybean products. They require however, a more in-depth understanding of the chemical, analytical and nutritional aspects of the products. The composition data also provide an indication of the specific processes that have been used to obtain the product. This is especially true for the data in Table 4. Along with the general description provided above, these data give thus a rather complete picture of the various properties and potential applications for each product. The total number and types of soybean products commercialized is clearly much larger that the ones listed in the tables. The tables only provide values for the main products. A large variety of different soy products are produced by different companies and for a large number of specific applications. Soy protein concentrates or heat or formaldehyde treated products for ruminant diets are an excellent example of this. The nutritional concentration as analyzed may not differ significantly from an ingredient listed but the nutritional value (due to a change in digestibility or degradability) may vary greatly. Since the tables only report composition that can be directly analyzed, such differences do not show up and are therefore not included.

The nutrient concentration of the different soy products in Tables 3 and 4 are compiled from a wide range of official sources and publications (NRC 1982, 1998, 2001; INRA-AFZ 2002; CVB 2000; FEDNA, 1994 and others). Besides completing the descriptive information provided in Table 2 the major purpose of the composition tables is to provide reference values that can be used to either evaluate the analytical data that are obtained in the laboratory or to further classify a specific ingredient. Since the data are obtained from a wide range of publications, the user may want to refer to the original publications if the sample corresponds more closely to one of the sources in his region. This is especially true in the case of soybean meals or soy by-products where crushing and further handling of the ingredient determine to a large extent the nutrient quality of the products.

The table values provide means based on a large number of samples covering many years and a wide range in origin. They cannot be used as standard values but only as reference points around which analysis of individual samples should be situated if they are to be identified by the specific ingredient name. Most individual samples will be within an acceptable statistical range of

these means (see Chapter 10). This level of precision is adequate for classification, storage and trading agreements, as those are generally based on a small set of analyses (proximate analysis or just humidity, protein and fat). More detailed analyses concerning the more difficult to determine nutrients may show larger variations from the means and possibly inconsistencies with some values above and others below the table values. This is often the case for amino acids or micro minerals. As such they may point to consistent differences in the production process of a given supplier or, alternatively, reflect problems in the analytical procedure. The experience and know-how of a lab technician in interpreting the result is here of great value. Cross-checking of values known to be affected in a similar fashion by a production process or a laboratory procedure may provide an explanation of a discrepancy and confirm the true value and classification for the ingredient.

For most users of soy products the detailed nutrient concentrations serve as a basis to formulate diets and to calculate total nutrient supply to animals. Since animal performance is determined by nutrient concentration and the relationship between nutrients, knowing the precise nutritional composition of the ingredients that make up the diet allows the prediction of animal performance and thus a detailed estimation of the value of each ingredient. Clear compositional descriptions of soy products are thus not only necessary for quality control reasons, but also for the evaluation in a diet or feeding operation. For precise formulations the analytical data on the ingredient in the plant should be used. The use of the table values, especially because of the large contribution that soy products make to the protein and amino acid supply, may lead to significant variations in nutrients between the formulated value and the real diets.

The compositional data in Table 4 includes nutrients that can be directly analyzed in a large and well equipped laboratory. Routine analyses, as carried out in standard quality control procedures or smaller laboratories, mainly concern the proximate analysis, the van Soest fiber components (with the exception of lignin) and the minerals calcium and phosphorus. These analyses (especially the proximate) are most often used to derive other nutrient values such as amino acids or energy. In advanced formulation systems they are generally combined with estimates of digestibility for each individual nutrient. No digestibility data are included here as this information is not necessarily the result of direct observations but rather of literature compilations and research conducted by feed compounders. Thus digestibility data used in formulationsystems can differ considerably among users and are generally considered proprietary information. In the Appendix tables (1, 2) specific energy values have been included however, because of their importance as descriptive parameters for individual soy products and because of their importance in classifying and referencing ingredients.

Table 3

Composition of some soy protein ingredients used in animal feeds

	Unit	Heat processed FF soybean seeds	SBM mechanically extracted	SBM solvent extracted 44	SBM solvent extracted 48	SBM solvent extracted 50	Soybean hulls	Soy protein concentrate	Soy protein isolate
Dry matter	%	89.44	89.80	88.08	87.58	88.20	89.76	91.83	93.38
Crude protein	%	37.08	43.92	44.02	46.45	48.79	12.04	68.60	85.88
Crude fiber	%	5.12	5.50	6.26	5.40	3.42	34.15	1.65	1.32
Ether extracts	%	18.38	5.74	1.79	2.1	1.30	2.16	2.00	0.62
Ash	%	4.86	5.74	6.34	6.02	5.78	4.53	5.15	3.41
NDF	%	12.98	21.35	13.05	11.79	9.95	56.91	13.50	-
ADF	%	7.22	10.20	8.76	7.05	5.00	42.05	5.38	-
ADL	%	4.30	1.17	0.75	0.90	0.40	2.05	0.40	-
Starch	%	4.66	7.00	5.51	5.46	3.28	5.95	-	-
Total sugars	%	-	-	9.06	9.17	9.29	1.40	-	-
Gross energy	kcal/kg	5013	-	4165	4130	4120	3890	4280	5370
Lysine	%	2.34	3.50	2.85	2.89	3.00	0.73	4.59	5.26
Threonine	%	1.53	2.21	1.80	1.84	1.90	0.73	2.82	3.17
Methionine	%	0.52	0.80	0.62	0.63	0.67	0.14	0.87	1.01
Cystine	%	0.55	0.77	0.68	0.73	0.73	0.16	0.89	1.19
Tryptophane	%	0.49	0.74	0.56	0.63	0.65	0.12	0.81	1.08
Calcium	g/kg	2.62	2.96	3.12	3.07	2.68	4.96	2.37	1.50
Phosphorus	g/kg	5.70	6.64	6.37	6.37	6.36	1.59	7.63	6.50
Magnesium	g/kg	2.80	2.84	2.72	3.03	2.88	2.23	1.85	0.80
Potasium	g/kg	15.93	20.28	19.85	22.00	20.84	12.15	12.35	2.75
Sodium	g/kg	0.29	0.33	0.18	0.18	0.88	0.10	0.55	2.85
Linoleic acid C18:2	%	9.70	2.87	0.64	0.80	0.56	1.21	-	-

FF Soybean = Full Fat Soybean; SBM = Soybean meal. For more detailed compositional data on soybean products see Appendix table 1, 2.
Source: compilation of NRC, INRA-AFZ, CVB, FEDN and selected suppliers
NDF = Neutral detergent Fiber; ADF= Acid Detergent Fiber; ADL = Acid Detergent Lignin (Klason Lignin)

Protein quality analyses (Urease Index, KOH soluble N, or PDI) are also not included as these do not generally differ among soy protein products. A number of these analyses do exist and they are important in evaluating soy protein quality especially in terms of digestibility of amino acids. Methods and optimal values for these tests are detailed further in Chapter 8. In many respects they refer to the residual values for the ANF listed in Table 5 but only the heat labile ones such as trypsin inhibitors, lectins and goitrogens (Liener, 2000). There is no proven

relationship between heat stable ANF and protein quality indexes. For many diets, especially in the case of diets for young animals, aquatic species and pets, the application and use of soy products depends to a much larger extent on the residual ANF than on the nutrient concentration. In such diets the more elaborated soy products such as SPC or SPI are more frequently used. Accurate analyses for most of these ANF are difficult to carry out and under most practical conditions the suppliers' guarantees are accepted. As Table 5 indicates, the range in some of these ANF is considerable and a thorough supplier classification is thus important. In many cases, if an analysis for a specific ANF is indicated, the choice to use external laboratories may be advised. External, specialized, laboratories will provide reliable results and generally are in a position to give advice as to the quality and level of an ANF relative to other samples of a similar product. If preference is given to install an analysis for ANF (generally trypsin inhibitor) in a laboratory the adherence to a ring test or systematic comparisons of results with a well established laboratory is necessary.

Table 4

Analytical characteristics of common types of soy protein products

Product type	Unit	Soybean seeds	SBM	Enzyme treated SPC	Alcohol extracted SPC	SPI
Humidity	%	10 - 12	10 - 12	6 - 7	6 - 7	6 - 7
Crude protein	%	33 - 17	42 - 50	55 - 60	63 - 67	>85
Fat	%	17 - 20	0.9 - 3.5	2.5	0.5 - 3.0	0.1 - 1.5
Ash	%	4.5 - 5.5	4.5 - 6.5	6.2 - 6.8	4.8 - 6.0	2 - 3.5
Oligosacharides	%	14	15	<1	<3.5	<0.4
Stachyose	%	4 - 4.5	4.5 - 5	<0.3	1 - 3	<0.2
Raffinose	%	0.8 - 1	1 - 1.2	<0.2	<0.2	<0.1
Trypsin inhibitor TIA	mg/g CP	45 - 60	4 - 8	1 - 2	2 - 3	<1
Glycinin	mg/g	150 - 200	40 - 70	<0.1	<0.1	<0.01
ß-conglycin	mg/g	50 - 100	10 - 40	<0.1	<0.1	<0.005
Lectins	ppm	50 - 200	50 - 200	<1	<1	<1
Saponins	%	0.5	0.6	0	0	0
Phytic acid bound P	%	0.6	0.6	0.6	0.6	-

SBM = defatted soybean meal; SPC = soy protein concentrate; SPI = soy protein isolate.
Adapted from: Hansen (2003) and Peisker (2001)

Anti-nutritional factors decrease in concentration as the elaboration increases and the soy product becomes richer in protein. The increased concentration of protein associated with a lower level of ANF increases the value of soy products in a proportionally greater fashion than the increase in cost of production. They are therefore much sought after products in specialty diets. However, they remain uneconomical in diets of older livestock animals as those animals are less sensitive to the ANF and their protein requirements can be met with lower concentrations and/or quality of proteins.

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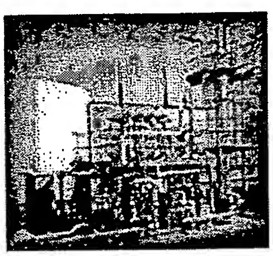
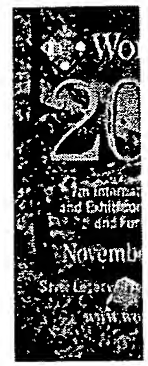




Protein Separations

Facilities available for preparation of various protein products from oilseeds, cereals and grains. These include:

- Protein concentrates
- Protein isolates
- Modified protein products
- Hydrolyzed protein products

Capabilities exist for process design of commercial facilities for production of protein products used in meat, dairy, beverage and bakery applications.

MANUFACTURING PROCESSES

I. Soy Protein Concentrates

Soy protein concentrates are prepared by removing soluble sugars from defatted soy flakes or flours. The remaining components are mainly proteins and insoluble polysaccharides.

By the removal of soluble sugars from defatted flakes , the protein content of the resulting soy product is increased and the undesirable oligosaccharides, which cause flatulence, are eliminated. Flatus is gas formed in the gut by bacterial fermentation of nondigestible carbohydrates. During extraction, most sucrose and most nondigestible oligosaccharides consisting of stachyose, raffinose, and a small amount of other carbohydrates are not removed. Sucrose and the total nondigestible oligosaccharides each constitute 8% of defatted flakes.

Different leaching methods are available to remove soluble sugars to yield concentrates. The basic approach is to extract the sugars while not solubilizing the protein portion. The major parameters in leaching or fractionation that affect yield and product quality are the starting material, extracting solvent, and extracting conditions.

Soy concentrate can be prepared from full-fat flakes produced by employing hexane as the oil-extracting solvent.

The amount of heat treatment during the preparation of defatted flakes influences the quality as well as yield of soy protein concentrate. Excessive toasting of defatted flakes, as indicated by a lower Nitrogen Solubility Index (NSI), reduces the amount of soluble sugars leached, resulting in a lower protein content in the final product. In addition, heating of flakes reduces the rate of soluble leaching. Because extraction is a continuous process, slow leaching has a major impact on production speed.

There are three common processes for manufacturing soy protein concentrate: aqueous alcohol wash, acid wash, and hot water leaching. In general, concentrate preparation involves countercurrent extraction.

1. Aqueous Alcohol Process

This process is commonly employed for producing commercial soy protein concentrates. Soluble sugars along with a small amount of soluble proteins are extracted by 50 to 70% aqueous alcohol. Due to the denaturation of protein by aqueous alcohol, most of the proteins become insoluble and remain with the insoluble polysaccharide. The alcohol was recovered by

flash desolventizing.

The preferred alcohol concentration is 60% by weight. Soy proteins appear to be least soluble in about 50% aqueous alcohol; their solubility increases on either side of that concentration. Excess water in the extraction solvent is to be avoided because of additional energy costs for removal and because an extremely wet soy protein cake tends to agglomerate, clogging the process system. The aqueous alcohol removed by evaporation from the alcohol water soy solubles is recycled to the extraction step.

The nitrogen solubility of soy protein concentrate made by the aqueous alcohol process is low, in the NSI range of 5 to 10. This low NSI is not necessarily related to functionality because the denaturation mechanism is different from that of toasting used to produce low-NSI soy meals. However, extraction with aqueous alcohol removes objectionable flavor and color to yield desirable soy protein concentrate products.

2. Acid Wash Process

The majority of soy proteins are globulins, which are insoluble in water in the regions of their isoelectric points. By the washing of defatted soy flakes with water near the isoelectric point of pH 4-5, soluble sugars are removed from the matrix of proteins and polysaccharide. After acid-water washing, the remaining materials are adjusted to near neutrality and dried. Usually, these products are spray-dried. Because some of the soy proteins are soluble at pH 4-5 , there is a reduction in the protein yield.

The acid wash process yields soy protein concentrate products with a relatively high NSI (about 65-75%) because severe denaturation steps are not introduced in the process and the proteins are neutralized before drying.

3. Hot Water Leaching Process

Proteins, including soy proteins, are easily denatured by heat and become insoluble in water. Moist heat is more effective for denaturation than dry heat. With water of high temperature, the small molecular weight materials, including soluble sugars, are extracted from the insoluble protein and polysaccharide matrix.

4. Other Processes

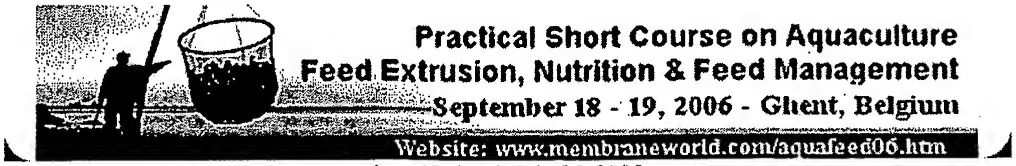
Another modified, "second-generation" soy protein concentrate of improved functionality is produced by successive pressure and cavitation, such as centrifugal homogenation at elevated temperatures and slightly alkaline pH, a high-NSI soy protein concentrate can be obtained from one that originally had a low NSI value. The highly soluble soy concentrate has functional properties similar to those of milk protein's.

II. Manufacture of Isolated Soy Protein

It includes aqueous extraction of soluble proteins and carbohydrates from defatted soybean flakes or soy flour; separation of the insoluble residue, followed by precipitation of protein at mildly acidic conditions; separation and removal of the soluble carbohydrates, proteins, and salts; and washing and drying of the protein. The protein can be neutralized and further processed into isolates with a variety of forms and functional properties.

III. SOY ISOLATE

Soybean flour is added to deionized water. The temperature and pH of the mixture during the extraction is kept at 55 degrees C. The pH of the mixture is kept at 8.5 – 9.5 using NaOH. After an hour the mixture is pumped into a centrifuge to separate the solids and the liquids. The liquid is held in a container while the solids were extracted again. (The difference between the beginning balance and the balance after centrifugation is attributed to the extra water used to clean the centrifuge baskets.) The solid residue is re-extracted using the same conditions. The proteins are precipitated out by HCl by bringing the pH to 4.55. All of the liquid fractions are pasteurized at 65 degrees C for a hour. The solution was then pumped into the centrifuge to separate the solids and the liquids. Then, separated solids are neutralized and spray dried to produce protein isolates.



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